TECHNICAL MEMORANDUM

gdc

EVALUATION OF ACUTE TOXICITY ASSOCIATED WITH THE JOINT CANNERY OUTFALL EFFLUENT

Prepared For:	StarKist Samoa (NPDES Permit AS0000019) COS Samoa Packing (NPDES Permit AS0000027)
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INTRODUCTION

StarKist Samoa and COS Samoa Packing (the canneries) discharge treated process water effluent through a common joint cannery outfall (JCO) and high-rate diffuser into the outer portion of Pago Pago Harbor. Seventeen years of monitoring have indicated no environmental degradation resulting from the discharge. The canneries submitted timely applications for the renewal of their respective National Pollution Discharge Elimination System (NPDES) permits (AS0000019 and AS0000027) to the U.S. Environmental Protection Agency (USEPA) in July 2005.

The existing permit requires semi-annual acute toxicity (bioassay) testing. Although the testing indicates acute toxicity may be present, the levels are low and the effluent is diluted to non-toxic levels well within the zone of initial dilution. The potential sources of toxicity are known and the parameters in question are regulated by means of effluent limitations.

PURPOSE

This memorandum presents the results of an evaluation of sources of acute toxicity associated with JCO effluent. The evaluation demonstrates that regulation of the sources of toxicity with existing and proposed effluent limitations will account for and regulate the apparent toxicity indicated by the past toxicity testing. In such a case it should no longer be necessary to conduct acute toxicity testing on the JCO effluent.

SOURCE OF INFORMATION REVIEWED

A total of fifteen semiannual acute bioassay summary reports, from 2001 through 2007, were considered[1]. These tests were conducted by EnviroSystems, Inc. and included analysis of ammonia on the sample as received at the laboratory. Bioassay tests performed prior to 2001 did not include appropriate ammonia testing, and were therefore not included in this evaluation. Monitoring data for copper, mercury, and zinc concentrations in the JCO effluent from the last four sampling events were also considered. The analyses for these metals were done from the eight grab samples used to create the composite bioassay samples. All data evaluated in this technical memorandum has previously been supplied to the American Samoa Environmental Protection Agency (ASEPA) and the USEPA.

RESULTS AND DISCUSSION

Four parameters that potentially affect the acute toxicity of the JCO effluent have been identified and are evaluated in this document. These are the only four parameters that exceed American Samoa Water Quality Standards (ASWQS) and the USEPA criterion maximum concentration (CMC) for saltwater in the USEPA National recommended Water Quality Criteria (NRWQC). The four parameters include: mercury (Hg), copper (Cu), zinc (Zn), and ammonia (ammonia, unless otherwise stated, is expressed as total ammonia as N). High oxygen demand is known to occur in the effluent and a modification to the testing method (i.e., aeration) has been applied (approved by USEPA) to eliminate or reduce dissolved oxygen (DO) as a variable. Since the effluent is immediately diluted by at least 300:1 at the discharge point, DO demand is not considered an environmental problem, as illustrated by many years of receiving water monitoring.

A summary of effluent concentrations of Hg, Cu, and Zn for StarKist and Samoa Packing for the four events mentioned above are provided in Attachment I. Concentrations of Hg, Cu, and Zn from each facility were flow-weighted to generate a combined composite effluent concentration for each sampling event (see Attachment I). The average and maximum effluent concentrations of Hg, Cu, and Zn, on a composite sample basis, are used to represent the concentrations in the associated bioassay sample and are presented in Table 1.

A summary of the effluent concentrations of ammonia (both as ammonia and un-ionized ammonia) are provided in Attachment 2[2]. The average and maximum total ammonia concentrations are also provided in Table 1 (data are provided in

[1] An extra test was conducted in May 2006 because the March 2006 bioassay tests were not aerated as required (for an annual total of three in 2006).
[2] Un-ionized ammonia was calculated from total ammonia, pH, and temperature. Note that these numbers may differ from those presented in the bioassay laboratory reports which appear to have been incorrectly calculated in some cases.

Attachment II). Although the metals data are limited, the results from the single grab samples indicate relatively little variability.

The CMCs for each of the parameters of concern are 1.8 µg/l, 4.8 µg/l, 90 µg/l, and 2.2[3] mg/l for Hg, Cu, Zn, and total ammonia, respectively. Based on the data summarized in Table 1, Hg and Cu as composite samples are below the criterion[4], but Zn and ammonia are above the respective CMCs. The dilution required, D_R, to reduce Zn and ammonia to the respective CMC is given by:

$$D_R = \frac{(C_E - C_A)}{(C_S - C_A)}$$

where (as listed in Table 1),

C_E = the effluent concentration
C_A = the ambient concentration
C_S = The CMC (water quality criterion)

The required dilutions for maximum concentrations of zinc and ammonia are (see Table 1) 3.3:1 and 35.5:1, respectively. The required dilutions for average concentrations are 2.9:1 and 21:1 for zinc and ammonia, respectively. The relatively low dilution required for Zn would indicate that ammonia has the greatest potential to affect acute toxicity. These required dilutions are achieved well within the zone of initial dilution (ZID) defined by a critical initial dilution (CID) of 313:1[5].

Table 1. Summary of Composite Bioassay Sample Concentrations

	Flow Weighted Composite[1]			Measured Value
	Hg	Cu	Zn	Total Ammonia
	µg/L	µg/L	µg/L	mg/L (N)
Average Effluent Concentration	0.111	3.60	260	46
Maximum Effluent Concentration	0.136	4.50	289	78
Criterion Maximum Concentration[2]	1.8	4.8	90	2.2
Ambient Concentration[3]	0.0062	0.296	2.093	0.005
Dilution Required for Average	NA	NA	2.9	21.0
Dilution Required for Maximum	NA	NA	3.3	35.5

[1] Based on recorded flows at StarKist and COS.
[2] USEPA NRWQC acute toxicity criterion
[3] Values as used by USEPA in the draft permit fact sheets

[3] The CMC is based on representative pH, salinity, and temperature for Pago Pago Harbor.
[4] It is noted that effluent monitoring data indicate that Cu and Hg, may be above the criterion at other times, but these data are not taken in the same sample as the bioassay test sample.
[5] "*Request for Water quality Certification and the Definition of Mixing Zones*". Submitted to ASEPA by **gdc**, 28 June 2007.

Table 2 presents the minimum, average, and maximum values of LC_{50} and associated acute toxicity units (TUa)[6]. The toxicity data are provided in Attachment III. Attachment III also includes the dilution required to reduce the toxicity to the "non-toxic" level of 0.3 TUa, the distance from the discharge point (diffuser port) needed to achieve this dilution, the time after discharge the required dilution is achieved, and the depth below the surface the dilution is achieved. The full data set considered here is provided in Attachment III.

Table 2.

Date	LC_{50} (% Effluent)	TUa	Calculated Required Dilution (D_r)
Minimum	10.23	2.00	6.67
Average	36.24	3.51	11.71
Maximum	50.00	9.78	32.58

The data presented in Table 2 shows that the required dilution to reduce the TUa to 0.3 is 6.7 and 11.7 for the minimum and average LC_{50}. This is similar to, but somewhat less than the dilution required to reduce the ammonia below the CMC. It is also seen, from the data in Attachment III that the distance and time from the discharge point to achieve the required dilution is 7 m and 9 sec for the worst case condition (lowest LC_{50}). This dilution is achieved 4 m from the bottom or 49m below the water surface. In all cases the toxicity is reduced to less than 0.3 TUa well within the ZID defined by a CID of 313:1.

Total ammonia and un-ionized ammonia are plotted versus LC_{50} in Figures 1a and 1b, respectively. Of the fifteen bioassay test results, one sample (August 2002) appears to be an outlier (presented as a hollow data icon in Figures 1a and 1b). Excluding this test result, the remaining data set indicates a distinct trend[7] of a lower LC_{50} with increasing ammonia concentration for both total ammonia and un-ionized ammonia concentrations. The trend for un-ionized ammonia with LC_{50} is highly statistically significant (with the outlier removed). The trend for total ammonia is similar but not as highly correlated.

[6] Acute toxicity units (TUa) are calculated as $100/LC_{50}$.

[7] Dataset R values are 0.48 and 0.68 for total ammonia and un-ionized ammonia respectively.

Figure 1a.
Total Ammonia versus LC_{50}

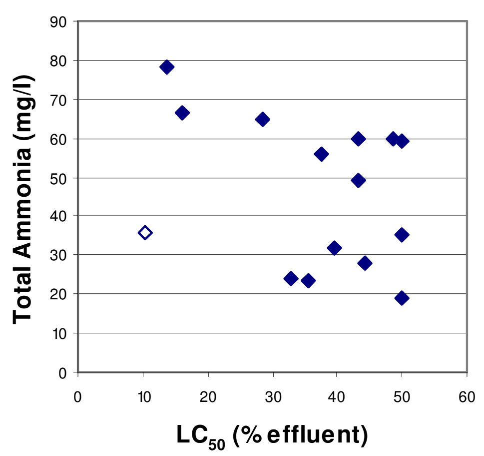
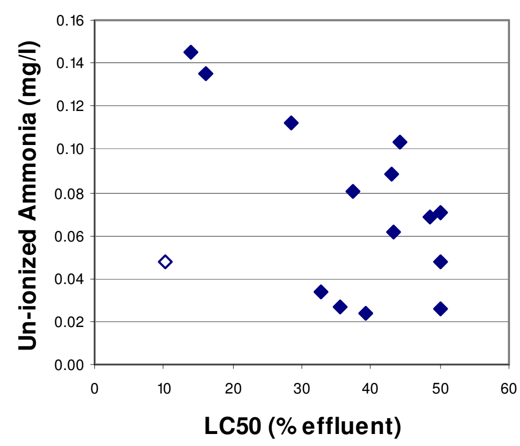


Figure 1b.
Un-ionized Ammonia versus LC_{50}



CONCLUSIONS

The data indicates that the acute toxicity is caused primarily by ammonia with a possible small contribution from zinc, and potential additional, but small, contributions from Cu, and Hg. The proposed effluent limitations, and associated small required dilutions and mixing zones relative to the ZID, for these parameters provide adequate regulation and protection of the receiving water for acute toxicity. Therefore, it is not necessary to conduct additional acute toxicity testing for the JCO effluent.

ATTACHMENT I

JCO Effluent Concentrations of Selected Metals

Sample Date	StarKist				COS				Flow Weighted Average		
	Flow	Hg	Cu	Zn	Flow	Hg	Cu	Zn	Hg	Cu	Zn
	MGD	µg/L	µg/L	µg/L	MGD	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Aug-05	2.44	0.0734			0.68	0.163			0.093		
	3.05	0.109			0.68	0.162			0.119		
	3.02	0.101			0.68	0.249			0.128		
	2.39	0.122			0.72	0.202			0.141		
	2.55	0.177			0.72	0.176			0.177		
	2.80	0.153			0.76	0.295			0.183		
	2.03	0.112			0.68	0.205			0.135		
	2.14	0.0912			0.72	0.165			0.110		
24-hour Composite									0.136		
Feb-06	1.98	0.107	3.63	264	0.88	0.123	1.8	118	0.112	3.067	219
	2.63	0.083	2.82	196	0.84	0.138	3.52	165	0.096	2.989	188
	2.60	0.298	2.17	146	0.84	0.086	3.67	200	0.246	2.536	159
	1.94	0.088	3.61	226	0.80	0.082	3.62	185	0.086	3.613	214
	1.95	0.096	3.67	340	0.80	0.128	2.46	334	0.105	3.318	338
	2.16	0.092	2.44	267	0.80	0.099	4.2	201	0.094	2.916	249
	2.53	0.102	1.79	190	0.88	0.084	3.32	272	0.097	2.185	211
	2.15	0.145	4.83	266	0.88	0.166	4.04	164	0.151	4.601	236
24-hour Composite									0.126	3.12	224
Nov-06	2.03	0.0802	2.92	200	0.72	0.0822	7.66	368	0.081	4.161	244
	2.12	0.082	3.93	272	0.72	0.131	12.4	433	0.094	6.077	313
	2.22	0.15	4.32	368	0.74	0.0917	8.29	371	0.135	5.313	369
	2.76	0.14	3.3	322	0.74	0.0797	6.2	266	0.127	3.913	310
	2.59	0.106	3.14	329	0.74	0.109	6.94	322	0.107	3.984	327
	2.40	0.104	2.79	246	0.80	0.0786	7.3	342	0.098	3.918	270
	2.41	0.158	3.35	278	0.80	0.0761	11.9	245	0.138	5.481	270
	2.60	0.155	2.28	195	0.80	0.0974	7.39	267	0.141	3.482	212
24-hour Composite									0.116	4.50	289
Feb-07	2.20	0.055	1.56	169	0.88	0.0517	7.82	700	0.054	3.349	321
	2.02	0.0586	2.31	296	0.80	0.0609	6.52	646	0.059	3.504	395
	2.06	0.0676	2.02	178	0.76	0.0666	6.25	588	0.067	3.160	288
	2.50	0.0501	1.43	142	0.76	0.0896	8.57	282	0.059	3.095	175
	2.48	0.0704	2.16	196	0.76	0.0739	5.02	251	0.071	2.831	209
	1.76	0.0427	1.81	166	0.76	0.0818	5.52	420	0.054	2.929	243
	2.16	0.0825	2.98	222	0.76	0.078	5.34	406	0.081	3.594	270
	2.15	0.081	2.13	159	0.76	0.0694	5.36	488	0.078	2.974	245
24-hour Composite									0.066	3.18	266
Summary of Individual Samples											
Minimum	1.76	0.043	1.43	142	0.68	0.052	1.8	118	0.054	2.18	159
Average	2.34	0.107	2.81	235	0.77	0.120	6.05	335	0.110	3.62	262
Maximum	3.05	0.298	4.83	368	0.88	0.166	12.4	700	0.246	6.08	395
Summary of Composite Samples											
Average									0.111	3.60	260
Maximum									0.136	4.50	289

ATTACHMENT II

JCO Effluent Ammonia Concentrations				
Date	Reported Effluent Ammonia	Calculated Required Dilution to meet 2.2 mg/l	Reported Effluent pH	Calculated Un-ionized Ammonia[1]
	mg/l as N		SU	mg/l
Mar-01	78.0	35.5	6.67	0.145
Nov-01	56.1	25.6	6.56	0.081
Mar-02	66.7	30.4	6.71	0.136
Aug-02	35.6	16.2	6.53	0.048
Mar-03	65.0	29.6	6.64	0.113
Aug-03	49.0	22.3	6.50	0.061
Mar-04	19.0	8.7	6.53	0.026
Oct-04	59.0	26.9	6.48	0.071
Mar-05	60.0	27.3	6.46	0.069
Sep-05	35.0	15.9	6.54	0.048
Mar-06	23.4	10.7	6.46	0.027
May-06	24.0	10.9	6.55	0.034
Nov-06	60.0	27.3	6.57	0.088
Mar-07	28.0	12.8	6.97	0.103
Sep-07	32.0	14.6	6.28	0.024
Minimum	19.0	8.7	6.28	0.024
Average	46.1	21.0	6.56	0.071
Maximum	78.0	35.5	6.97	0.145

[1] Calculated un-ionized ammonia based on effluent total ammonia, ph reported by lab, and a standard temperature of 20ºC.

ATTACHMENT III

Acute Toxicity Results and Required Dilution							
Date	LC_{50}	TUa	Calculated Required Dilution (D_r)	Distance from Discharge	Time from Discharge	Distance Above Bed	Distance Below Surface
	% Effluent			(m)	(sec)	(m)	(m)
Mar-01	13.80	7.25	24.2	5.46	6.4	3.06	50.58
Nov-01	37.50	2.67	8.9	2.41	2.2	0.64	53.00
Mar-02	16.10	6.21	20.7	4.77	5.4	2.53	51.11
Aug-02	10.23	9.78	32.6	7.13	8.7	4.33	49.32
Mar-03	28.4	3.52	11.7	2.98	3.0	1.11	52.54
Aug-03	43.2	2.31	7.7	2.18	1.9	0.45	53.20
Mar-04	>50.0	2.00	6.7	1.97	1.6	0.28	53.37
Oct-04	>50.0	2.00	6.7	1.97	1.6	0.28	53.37
Mar-05	48.5	2.06	6.9	2.01	1.7	0.31	53.34
Sep-05	>50.0	2.00	6.7	1.97	1.6	0.28	53.37
Mar-06	36.6	2.73	9.1	2.46	2.3	0.68	52.97
May-06	32.7	3.06	10.2	2.67	2.6	0.86	52.79
Nov-06	43.1	2.32	7.7	2.18	1.9	0.45	53.19
Mar-07	44.1	2.27	7.6	2.15	1.9	0.42	53.22
Sep-07	39.4	2.54	8.5	2.33	2.1	0.57	53.07
Minimum	10.23	2.00	6.7	1.97	1.6	0.28	49.32
Average	36.24	3.51	11.7	2.98	3.0	1.08	52.56
Maximum	50.00	9.78	32.6	7.13	8.7	4.33	53.37